out the North American ranges of the species. The casual records are added separately, but, we regret to see, with altogether too little specific data. The egg dates are generalized records taken from a great mass of data and are usually given for one or two states with only inclusive dates.

Disclaiming any attempt at critical treatment of the questions of relationship, our author, however, occassionally adds comments of this character. One of the most interesting of these relates to that peculiar form *Uria ringvia,* which some ornithologists consider a distinct species, and others a mere aberration of *Uria troille.* Mr. Bent presents the data on both sides of this question, but seems to think that the bird is a distinct species. Other important critical remarks are given under *Gavia arctica arctica,* which is shown to be extralimital so far as North America is concerned. The records ascribed to this are considered all properly referable to the recently described *Gavia viridigularis* Dwight, which is here treated as a subspecies of the European *Gavia arctica.*

"The Life Histories of North American Diving Birds" is unusually well illustrated. The 43 black and white full-page plates represent nearly twice that many scenes in the life of the various species, and consist of half tones showing habitat, nests, eggs, young, and sometimes also adult birds; many of these are of much scientific interest and add greatly to the instructiveness and interest of the book. The 12 colored plates represent the eggs of many of the species. These are apparently of natural size, but there is, unfortunately, no indication on the plates or elsewhere that this is the case.

It is manifestly impossible in the brief space of a review to do justice to this work, crowded as its pages are with information; but one thing we may say, and with truth, that "The Life Histories of North American Diving Birds" is one of the most important contributions to North American ornithology, and will for a long time be the recognized authority on biography of the species that it treats.

HARRY C. OBERHOLSER

SPECIAL ARTICLES

VISIBILITY OF BRIGHT LINES

THERE has been a material amount of investigation regarding the visibility of dark lines against a light background. Seeing a linear object is much easier than seeing a spot of similar minimum dimension, and totally different from resolving parallel lines, which must be distinct as a whole before there is the least chance of resolution. In general terms distinct lines or spots can, with difficulty, be resolved when distant 1′, to judge from the average of many experiments,[1] depending on relative contrast of the objects and other experimental conditions, and barring occasional cases of highly abnormal acuity, $V = 5$–8, such as those reported by Cohn.[2] A single spot, white on black or black on white can be detected by one with fairly keen vision down to a diameter of 30″, by an occasional observer to half this value, again depending on conditions and background, with some advantage on the side of white on black as being less adversely affected by irradiation. A careful distinction should be drawn between the case here considered of contrasted bodies returning light diffusely, and that of directed specular reflection as from a mirror reflecting the sun. This latter visibility, as in the observation of a star, seems to depend chiefly on the minimum stimulus value for the retina under the existing conditions of adaptation. Humboldt records in his "Cosmos" the observation of a heliograph mirror when subtending an angle of only 0″.43, and Professor Hosmer (M.I.T.) tells me that his students could readily pick up signals from a very small heliograph at about 20 miles—angle subtended a scant 0″.2.

Some experiments by Barnard[3] with a dark wire 0″.009 inch in diameter showed that it was visible when suspended against moderately bright sky up to 356 feet, angle subtended 0″.44. a figure down to something like 1/60 the diameter of the smallest spot ordinarily visible.

[1] Nagel, "Handbuch d. Physiologie d. Menschen," III., 340.

[2] *Berl. Klin. Woch.,* 1898, 20–22.

[3] *Pop. Ast.,* 1898, p. 1.

Later Lowell[4] tried out a similar experiment with the result of finding his wire visible easily at 0″.89, with some difficulty at 0″.83 and glimpsed down to 0″.69. Evidently his contrast conditions were less good than Barnard's. A further test by Slipher and Lampland[5] showed the wire disappearing from certain vision at 0″.86, while a dark blue line on a white disk held down to 0″.83. W. H. Pickering[6] experimenting with a dark human hair against open sky found it easily visible when subtending an angle of 1″.13, easily glimpsed at 0″.97, occasionally glimpsed at 0″.83, and quite invisible at 0″.72.

Taking up the converse case the writer first tried a German silver wire 0.01 inch diameter stretched zigzag in lengths of several feet over a dark plank bulkhead. The reflectivity of this varied from about 0.06 to 0.12, *i. e.*, a very dark gray. The test was in full sunshine and the observers, the place being the range of the Massachusetts Rifle Association, were a group of riflemen, keen of sight and experienced in close observation. The terrain was laid off in 50-foot spaces and the results were as follows: Wire vanished across lighter parts of background at 75 feet (2″.3) while across the darkest of that background the wire persisted up to 200–250 feet, beyond which it was invisible save for specular glints especially at twists. To summarize:

Angular Diameter	Appearance
1″.11	Parts against dark background were plain.
0″.86	Portions seem distinctly but not steadily.
0″.69	Visible at specular spots, difficultly glimpsed elsewhere.
0″.46	Visible by specular reflection only.

A second test with some of the same observers was made, using a background of black paper (coefficient .045), white thread 0.008 inch in diameter, and drawn tungsten wire 0.005 diameter. The paper was nailed to the former bulkhead and wire and thread stretched zigzag as before. Observed in bright skylight, also in moderately bright sunshine. The wire was visible with difficulty to one observer at 150 feet and beyond this disappeared utterly. To the others it could be fairly made out only at 100 feet. The thread, which was much brighter than the wire, began to be lost in parts at 200 feet, but in sunshine held rather indistinctly but unmistakably to 300 feet. When the sun went in the thread was lost at about 200 feet. To summarize again

	Angular Diameter	Appearance
Wire	0″.86	Limit for all but one observer.
	0″.57	Fairly seen by one observer.
Thread	0″.92	Network distinct all over.
	0″.69	Parts distinct in sunshine.
	0″.55	Parts evident in sunshine.
	0″.46	Near limit of visibility. Only small bits of network seen.

In the case of the thread the brightness contrast between thread and background was about 16:1. With brilliant sunshine and a background of even deader black there might have been a slight further gain, but we were evidently close to the limit. It is rather noteworthy that there should be so near an agreement throughout as between dark on bright and bright on dark, but barring specular direct reflection the brightness contrast which determines visibility is not widely different in the two cases, and the *minimum visibile* for a linear object with strongly contrasted background would appear to be about 0″.5 ±. It is certainly less than 1/50 the *minimum visibile* for a round spot giving similar contrast, a remarkable evidence of the efficient coordination of retinal impressions.

Boston Louis Bell

[4] *Bulletin Lowell Obs.*, No. 2.
[5] *Lowell Obs. Bull.* No. 10.
[6] *Pop. Ast.*, 23, 578.

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